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High-growth firms and innovation: an empirical analysis for Spanish firms

Agustí Segarra · Mercedes Teruel

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Abstract This paper analyses the effect of R&D investment on firm growth. We use an extensive sample of Spanish manufacturing and service firms. The database comprises diverse waves of Spanish Community Innovation Survey and covers the period 2004–2008. First, a probit model corrected for sample selection analyses the role of innovation on the probability of being a high-growth firm (HGF). Second, a quantile regression technique is applied to explore the determinants of firm growth. Our database shows that a small number of firms experience fast growth rates in terms of sales or employees. Our results reveal that R&D investments positively affect the probability of becoming a HGF. However, differences appear between manufacturing and service firms. Finally, when we study the impact of R&D investment on firm growth, quantile estimations show that internal R&D presents a significant positive impact for the upper quantiles, while external R&D shows a significant positive impact up to the median.

Keywords High-growth firms · Firm growth · Innovation activity

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1 Introduction

The potential effect of innovation on firm growth is an important issue for economists and policy makers because not only does it improve the understanding of the determinants of firm growth and survival patterns, but it also has implications for industrial policy. From the European Commission, there is consensus on promoting high-growth firms (henceforth HGFs), in particular in those economies which are economically struggling and with a low capacity to create job opportunities.[1] Given this scenario, this paper aims to analyse the role of R&D activities on firm growth for Spanish innovative firms. Furthermore, the analysis focuses on the impact of R&D performance on the prevalence of HGFs.[2]

The empirical literature has concluded that HGFs are a small group of firms that have a higher capacity for creating new jobs and economic growth (Henrekson and Johansson 2010; Falkenhall and Junkka 2009;

[1] For instance, see European Commission (2011).

[2] This study only considers incumbent firms since exiters are excluded. Here, we only consider organic growth, also called internal growth, which occurs when the firm grows from its own business activity.

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Schreyer 2000). However, there are still few studies analysing HGFs, perhaps because of the scarcity of representative longitudinal databases (Henrekson and Johansson 2010). Although the impact of HGFs may have been overestimated, it is clear that for countries with high unemployment rates, the analysis of HGFs might be of special interest in order to promote employment and increase market dynamism.

Innovative HGFs are of special interest since they are able to push the technological frontier, but they face higher risks in comparison with those that do not innovate (Hölzl 2009; Coad and Rao 2010). In this regard, R&D and innovation are generally considered to be key drivers of firm performance. However, the intrinsic risks of innovative activity may prevent firm growth in some cases and promote it in others. Innovative HGFs have different characteristics from their non-innovative counterparts. For this reason, they should be monitored and their determinants should be analysed to determine implications for public policy.

Despite the interest in understanding how a firm becomes an HGF, not much is currently known about how firms grow and what the impact of innovation activities on firm performance is. Empirical evidence shows HGFs appear in all sectors and regions but predominate in high-tech manufacturing industries and KIS services. In general HGFs tend to be younger and smaller (Schreyer 2000), represent a small proportion of new firms (approx. 5 %), exhibit greater capacity for job creation (Storey 1994) and improve productivity at country level (Bartelsman et al. 2005). Some empirical studies found that firm size and age impact negatively on the growth trajectories of firms but positively affect their survival capacity (Audretsch 1995). Also, for an extensive sample of Spanish firms across the period 1996–2003, López-García and Puente (2012) find that HGFs sustain their expansion with relatively more debt and fixed-term contracts than their counterparts.

On a national level, HGFs play an important role in order to promote economic growth and generate employment. Initially, Birch (1979) found empirical evidence that a small number of US firms created the majority of jobs. However, we may consider that the capacity of HGFs to create employment in countries with high unemployment might be exaggerated. On the one hand, various studies found that the potential of new firms to create employment has been about one-third in contrast to two-thirds for established firms (Storey 1994). On the other hand, Birch's seminal contribution has been criticized for methodological deficiencies and overestimation of the capacity of new firms to generate employment (Davis et al. 1996; Almus 2002). However, for a review of six OECD countries, Schreyer (2000) concludes that HGFs account for a disproportionately large part of net job creation in all countries analysed. In summary, recent decades have witnessed an increasing debate about the role of HGFs and, in spite of diverse data sources and methodologies, the empirical evidence shows a broad consensus about the fact that only a small number of firms contribute to net employment creation.

This paper uses data from the Technological Innovation Panel (henceforth, PITEC) that incorporates data from some waves of Spanish Community Innovation Survey (CIS) surveys and covers the period 2004–2008. Our sample comprises an extensive sample with 3,807 Spanish firms. Furthermore, Spain is a particularly interesting case because it is considered to be a moderately innovative European country (European Commission 2010). This research has two key aims. First, we determine the factors that increase the probability of a firm to become an HGF. Second, we analyse the determinants of firm growth across the distribution. We contribute to the empirical literature of firm growth in two different aspects. First, we analyse the impact of two innovation sources: internal and external R&D investment. Second, while the majority of the studies have not highlighted the differences at sectoral level, here we analyse the differences between manufacturing and service industries.

The paper is structured as follows. The next section provides a short literature survey on HGFs and innovation. Section 3 presents the CIS data and descriptive statistics. Section 4 presents empirical results showing the determinants of becoming an innovative HGF and the determinants of firm growth, and gives the results of probit regressions and quantile estimations. Section 5 summarises the findings and discusses policy implications.

2 Literature review

2.1 A brief review of the literature on high-growth firms

Research on firm growth has focused on whether firm growth is independent of firm size. In general the starting point is the well-known 'Law of Proportionate Effect' or 'Gibrat's law'. Gibrat (1931) observed that firm size distribution followed the lognormal distribution very closely, and he concluded that firm growth should follow a random process in order to obtain the lognormal firm size distribution. In general, empirical evidence shows that initial firm size has a negative impact on firm growth. Hence, empirical evidence rejects Gibrat's law where the expected growth rate is independent of initial firm size.

Furthermore, previous empirical evidence found different outcomes that contradict Gibrat's law. First, firms of a given size will grow faster (or slower) than firms of other sizes; second, firms that grow faster (or slower) in one time period will grow faster (or slower) in a later time period; third, firm growth depends negatively on firm age; and fourth, some factors will powerfully and consistently explain firm growth.

These incompatibilities with Gibrat's law were noticed by Sutton (1997). In his review of 'Gibrat's Legacy', he found that half a century of testing had revealed several statistical regularities that were incompatible with firm growth being essentially random—most notably that small firms appeared to grow faster than large ones and that growth rates were serially correlated.[3] Also, a recent review by Coad (2009) of more than 20 studies concludes that the overall evidence on the serial correlation of growth rates is mixed. Of particular interest for the current paper is that this author finds that some firms grow exceptionally fast and increase in size in a relatively short space of time.

With respect to the empirical evidence of HGFs' capacity to create jobs, there are different stylized facts. First, although there is no consensus on the contribution of HGFs to job creation, their impact is non-negligible. For instance, Birch's contributions (1979, 1981) determined new U.S. firms create around 90 % of labour opportunities, recent research fixed the employment creation of new firms at about 1/3 as against 2/3 of incumbents. Storey (1994) mentions that 4 % of the fast-growing firms in his sample create about 50 % of the employment in this cohort over a decade. Second, HGFs are part of a replacement effect in the market. In particular, Falkenhall and Junkka (2009) point out that there is a replacement process where HGFs in one period are replaced by those that will come into being in the next one. They consider that this replacement "*is a part of a natural process of ongoing structural transformation or creative destruction, where winners on the market are selected in accordance with the theory of competence blocks*". However, recent studies have shown that some HGFs undergo an explosive transformation at firm level in a short period. For this reason one of the key issues in the empirical literature and at policy level has been to define HGFs and find their determinants.

Parker et al. (2010) present an interesting survey on HGFs. First, they highlight the lack of a commonly accepted denomination used for 'high-growth' firms. In this regard, the literature has referred to fast-growth firms (Deutschmann 1991; Storey 1994, Almus 2002); high-growth impact firms (Acs et al. 2008), HGFs (Schreyer 2000), "superstar" fast-growth firms (Coad and Rao 2008), rapidly expanding firms (Schreyer 2000), and gazelles (Birch 1981, among others). Second, they point out that there are different definitions of HGFs.[4] Some of these terms that describe the intense growth process in a short period of time are used interchangeably, but they are essentially quite different. For instance, 'fast-growth' implies growth over time related to speed, whereas 'high-growth' alludes to quantity. Third, they show that the literature also uses a variety of growth indicators, of which sales, employment, profitability and market-share are the most common.[5] Some authors apply the so-called Birch index (i.e., the combination of employment growth measured in absolute and relative terms, as a growth measurement to relate to previous literature) (Schreyer 2000). Finally, they indicate that a size or threshold is applied. For instance, the OECD (OECD/Eurostat 2008) recently proposed defining HGFs as those with ten or more employees. The term

[3] Initially, Hart and Oulton (1996) and Singh and Whittington (1968) found evidence that smaller firms grew faster than their larger counterparts, and Wagner (1992) found that those firms that grew faster in one period of time were more likely to grow faster in subsequent periods.

[4] Authors have used different periods of observation. For instance, Henrekson and Johansson (2010) consider HGFs to be those that grow more than 20 % every year for a period of 3 or 4 years, while Fritsch and Weyh (2006) used the longest period of 18 years.

[5] Daunfeldt et al. (2010) present an exhaustive panel of growth indicators and growth measurements used in empirical literature. They define HGFs by employment and sales and add definitions of added value and productivity.

"gazelle", on the other hand, is applied to the subset of firms that are less than 5 years old.

More recently, some empirical facts about HGFs have also emerged. First, they are found in all regions (Schreyer 2000). Second, they are more R&D intensive than normal-growing firms. Third, HGFs are found in almost every sector; hence, an exclusive focus upon technology-based sectors would exclude the vast bulk of HGFs (Acs and Mueller 2008). Fourth, the patterns of growth among HGFs cannot be sustained during long periods of time (Delmar et al. 2003; Garnsey et al. 2006; Acs and Mueller 2008; Hull and Arnold 2008). Fifth, Falkenhall and Junkka (2009) point out that this volatility is due to the replacement effect of current HGFs by other future HGFs. Finally, HGFs tend to be younger and smaller than their normal-growing counterparts (Schreyer 2000). However, Henrekson and Johansson (2010) pointed out that "*it is young age more than small size that is associated with rapid growth*".

Finally, some studies have shown the impact of new business formation and HGFs on regional development differs greatly. Evidence shows that HGFs and new firms have a particularly positive effect on regions with high productivity, while the impact of HGFs on regions with low productivity was smaller (Fritsch and Mueller 2008).

2.2 Innovation and firm growth

The effect of innovation activity on firm performance has received a great deal of attention (Segarra and Teruel 2011). Recently, the literature has emphasized the existence of "absorptive capacity" (Cohen and Levinthal 1989), a phenomenon that is the result of the complementarities between internal and external R&D. The literature remarks on the existence of a dual dimension of R&D investment. First, the firm invests in internal R&D activity and increases its ability to capture external knowledge. Second, the firm invests in external R&D and captures the knowledge developed outside the firm (Fabrizio 2009; Catozzella and Vivarelli 2007).

Empirical evidence about the effect of innovation activity on firm growth is mixed, however. For instance, Smallbone et al. (1995) showed that the management of product and market development most consistently distinguished HGFs from other firms, although for these authors, "*it is true that a few firms could survive for 10 years without paying some attention to product and market development, to achieve high growth firms need to be particularly active in this respect*". In line with these results, in a sample of 1,480 growing Canadian SMEs, Baldwin (1994) found that 30 % of firms considered that their success was down to their innovation strategy.

Furthermore, the scarce evidence at country level has found that there are some differences between countries. For a sample of SMEs from 16 countries using CIS data, Hölzl (2009) finds that R&D effort and innovativeness are higher for high-growth SMEs in countries close to the technological frontier. According to these results, there are interactions between the effort of innovation, the returns on innovation and the technological level of the country.

Coad and Rao (2008) also analysed the relationship between innovation and sales growth for incumbent firms in high-tech sectors. Using a quantile regression approach, they observe that innovation is of crucial importance for a handful of 'superstar' fast-growth firms. They point out the existence of a "paradox". On the one hand, there is a wide range of theoretical and empirical contributions that highlight the importance of innovation for firm growth. On the other hand, there is a scarcity of strong results showing that innovation and firm growth are associated. This interpretation has also been emphasized by Stam and Wennberg (2009) where R&D efforts show a significant impact on the fastest growing firms.

These difficulties may be due to the fact that the innovation activity is a rather complex process. On the one hand, converting R&D into innovation and finally contributing to the firm's performance may take a long time (Coad and Rao 2008). On the other hand, in general, the innovation process is rather risky and uncertain. Hence, an in-depth study into the relationship between innovation activity and firm growth needs to be made (Cefis and Orsenigo 2001; Coad and Rao 2010). In accordance with this, Cainelli et al. (2006) analysed a set of service firms and found that innovation has a positive influence on firm growth and productivity.

3 Descriptive statistics and empirical methodology

3.1 PITEC and the measurement of high-growth firms

We use the Spanish Technological Innovation Panel (henceforth, PITEC). PITEC is the result of the collaboration between the Spanish National Statistics Institute and the COTEC foundation with the aim of providing data from the CIS. PITEC integrates information from CIS-4, CIS-2008 and CIS-2010 for Spanish firms covering the period 2004–2008. The PITEC database includes firms which have been making some kind of technological effort, consequently the database is not representative of the whole population. PITEC data has two main advantages. First, it contains detailed information of innovation behaviour at firm level. Second, it is a panel data set that facilitates detailed analysis of firms' innovation behaviour over time.

Our final database was subjected to a process of filtering. First, we selected firms from the manufacturing and service sectors (including high-tech and low-tech sectors). Second, we excluded firms with three or fewer years of observation. Third, firms that had experienced a sudden change such as mergers or acquisitions were excluded. Fourth, we restricted observations to those with a growth or decline of sales and employees smaller than 250 % per year in order to control the presence of outliers. Finally, we considered firms that at the beginning of the period of observation had ten or more employees. Although the filtering process reduced the initial database from 12,813 to 3,807 firms, the sample gained in the consistency of the data.

Departing from this final selection of firms, we identify HGFs. We consider HGFs those firms that grew by 80 % between the years 2004 and 2008 and that have at least ten or more employees in the initial period. Our definition of HGFs is based on growth in terms of employees or sales.[6] Therefore, there are two groups of HGFs: employee HGFs and sales HGFs. Our final panel data has 3,807 firms, of which 419 (11.01 %) were HGFs from the sales point of view and 198 (5.12 %) were HGFs from the employee point of view. Those percentages are in line with international empirical evidence.

Table 1 Mean growth rate in manufacturing and service firms for each decile (2005)

Deciles	Manufacturing firms		Service firms	
	Employees annual growth rate (%)	Sales annual growth rate (%)	Employees annual growth rate (%)	Sales annual growth rate (%)
1	−12.50	−17.20	−13.81	−17.59
2	−6.60	−9.15	−5.26	−5.14
3	−3.28	−4.78	0.00	−0.40
4	−0.41	−1.40	0.00	2.27
5	0.00	1.56	2.71	5.42
6	1.60	4.53	5.74	8.82
7	4.46	8.11	9.63	14.29
8	8.33	13.62	16.67	22.90
9	16.16	25.86	29.54	38.55
Total sample	3.72	1.38	9.75	5.84

Source: PITEC and authors

The descriptive statistics in Table 1 provide interesting results:

(a) The average growth rate is higher for service than for manufacturing sectors both in terms of employees and sales.

(b) The dispersion of growth rates is higher in service sectors in comparison with manufacturing sectors.

(c) Firm growth is faster in terms of employees than in terms of sales, both for manufacturing and service sectors.

3.2 Dependent and explanatory variables

We consider two types of dependent variables. The first type captures whether a firm becomes an HGF. *HGFempl* is a dummy variable indicating whether a firm becomes an HGF measured in employees; *HGFsales* is a dummy variable indicating whether a firm becomes an HGF measured in sales. In this first step, we will consider those firms investing in R&D. Hence, we consider *RD* as a dummy variable indicating that a firm invests in R&D.

[6] Recently the OECD and Eurostat in the *Manual on Business Demography Statistics,* European Communities/OECD 2008, define HGFs as: "*All enterprises with average annualised growth in employees (turnover) greater than 20 % a year, over a 3-year period, and with 10 employees at the beginning of the observation period*". Note that the provisional size threshold of ten or more employees holds for both the turnover and employment measures. The advantage of this is that the initial population is the same, regardless of whether growth is measured in employment or turnover. Moreover, it would be difficult to apply a consistent turnover threshold across all countries participating in the data collection.

The second group measures the growth rate between 2004 and 2008. *grEmpl* indicates the growth rate between 2004 and 2008 measured in terms of employees, while *grSales* indicates the growth rate between 2004 and 2008 measured in terms of sales.

Hence, our dependent variable is sales and employment growth between 2004 and 2008. There are numerous ways in which firm size can be measured empirically. Employment and sales are the most frequent indicators, but sometimes other measures such as assets (Coad and Hölzl 2010) are used. Delmar (1997) points out that little congruence is to be found among the growth measures used across studies. Both of the most frequently used measures—sales and employment growth—have advantages and disadvantages. One drawback of the sales variable is inflation (Delmar et al. 2003). Hence, we deflated this variable, as well as the rest of monetary variables, by an industrial price index. Given that policy makers are concerned with reducing the unemployment rate, employment is generally considered to be an interesting measure of firm growth (Storey 1994). However, employment growth is highly affected by increases in labour productivity (Delmar et al. 2003) and by the distance from the sectoral minimum efficient scale (MES) that enables them to survive (Sutton 1997).

Regarding the explanatory variables, Table 2 presents the variables used in the empirical estimations:

Table 3 shows the statistical descriptive of HGFs and non HGFs. The main characteristics are the following:

(a) The presence of HGFs is higher in the service sectors than in manufacturing.
(b) HGFs grow faster than their counterparts regardless of the sector. However, their size is smaller.
(c) HGFs are more prevalent in service than in manufacturing sectors.
(d) On average, in terms of employees, HFGs also demonstrate large growth rates in terms of sales. While in terms of sales HFGs do not display such a large growth rate in terms of employees.
(e) HGFs show higher investment in R&D per employee, in particular internal R&D, and tend to cooperate more in R&D projects than their counterparts.
(f) Although the presence of new firms is scarce among HGFs, their presence is bigger than within non-HGFs. Furthermore, the percentage of new firms is lower when we consider HGFs in terms of sales than when we consider HGFs in terms of employees. Hence, this can be explained by the fact that a new firm may have more difficulties in becoming an HGF in terms of sales than employees.
(g) HGFs are not oriented to international markets, since they present a low percentage of exports. Furthermore, on average there are no significant differences between HGFs and non-HGFs.

Table 2 Variables and description

Variables	Description
Size	Natural log of firm size
New	Dummy variable indicating that a firm is newly created
intRD extRD	Dummy variables which indicate if the firm invests in internal or external R&D
R&D effort	Natural log of internal and external R&D per worker
intR&Deffort extR&Deffort	Log expenditure on internal and external R&D divided by the number of employees
KL	Natural log of physical capital investment per employee. This variable is deflated by a price index
Group	Dummy variable which indicates if a firm belongs to a group of firms (a group made up of a parent and subsidiary firms)
Coop	Dummy variable which indicates if a firm cooperates in a joint R&D project with other firms
Export	Percentage of exports over total sales

According to CIS, internal R&D are those in-house systematic R&D activities which have the purpose of increasing the knowledge in order to create new or better products and processes. Internal R&D includes researchers and technicians' wages, equipment, software, licencing, and others. External R&D refers to the acquisition of external R&D services through a contract

Figure 1 shows the kernel density of these variables and distinguishes between HGFs (employees and sales) and their counterparts. First, we must highlight that HGFs invest more in internal and external R&D in comparison with those firms that are not classified as HGFs. Second, the differences between both groups are significantly higher when considering the effort put into external R&D as opposed to internal R&D. Finally, the figure also reports the Kolmogorov–

Table 3 Descriptive statistics (average values) in 2005

Statistic	HGFs in terms of employees		Non-HGFs in terms of employees		HGFs in terms of sales		Non-HGFs in terms of sales	
	Services	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services	Manufacturing
Employee growth 2004–08 (%)	143.75	133.28	7.83	−0. 15	71.86	32.75	13.68	−0. 13
Sales growth 2004–08 (%)	144.50	128.90	42.26	23.11	198.60	151.74	22.86	13.84
R&D effort	2,1925.25	9,555.01	10,947.38	5,593.52	1,6874.74	7,775.11	11,242.18	5,533.33
Internal R&D effort	17,774.3	5,202.84	8,629.70	3,063.78	13,178.41	4,771.36	8,957.65	2,993.32
External R&D effort	1,416.86	920.68	953.00	845.59	1,477.02	1,023.82	907.49	834.64
Firm size (Median)	62	43	92	65	90	47	85	65
New firms (%)	5.26	2.38	0.23	0.36	1.75	2.42	0.62	0.26
Internal R&D activity (%)	70.17	69.05	49.19	63.96	66.67	71.37	48.45	63.55
External R&D activity (%)	30.70	38.09	24.07	32.75	35.67	34.68	22.55	32.75
Investment per worker	9,662.86	20,400.41	17,463.45	10,073.9	16,333.71	13,572.55	16,600.9	10,073.83
Group (%)	37.72	36.90	35.99	36.37	42.69	38.71	34.82	36.21
Export (%)	5.79	16.11	4.28	23.11	3.80	23.25	4.60	22.93
Cooperation (%)	43.86	40.48	32.52	31.84	44.44	39.11	31.60	31.53
Observations	114	84	864	3,624	171	248	807	3,460

Source: PITEC

HGF high-growth firms

grL0804 and grS0804 are the percentage of change between 2,004 and 2008. R&D effort is the value of R&D investment per employee. New, Internal R&D activity, External R&D activity, Group and Cooperation are dichotomic variables (these variables indicate the average). Export is the percentage of sales which are exported

Smirnov tests, which show that the null hypothesis of equality of distributions is strongly rejected for both groups of firms.

3.3 Econometric methodology

In order to analyse the relationship between the innovation process and the behaviour of HGFs, we will apply a two-step procedure. First, following López-García and Puente (2012), we estimate a probit model in order to establish the main determinants of the probability of being an HGF. The dependent variable is a categorical variable, which adopts the value of 1 for those firms which grew 80 % or more between the years 2004 and 2008, and zero otherwise (OECD, 2008). Given that we analyse the impact of R&D activities on the probability of being an HGF, our dependent variable is observed only if the firm invests in R&D. Consequently, the estimation will be biased towards those firms that invest in R&D.

Hence, we apply a probit model correcting by sample selection. Our selection equation considers the probability that a firm invests in R&D depending on a set of determinants related by the current literature and

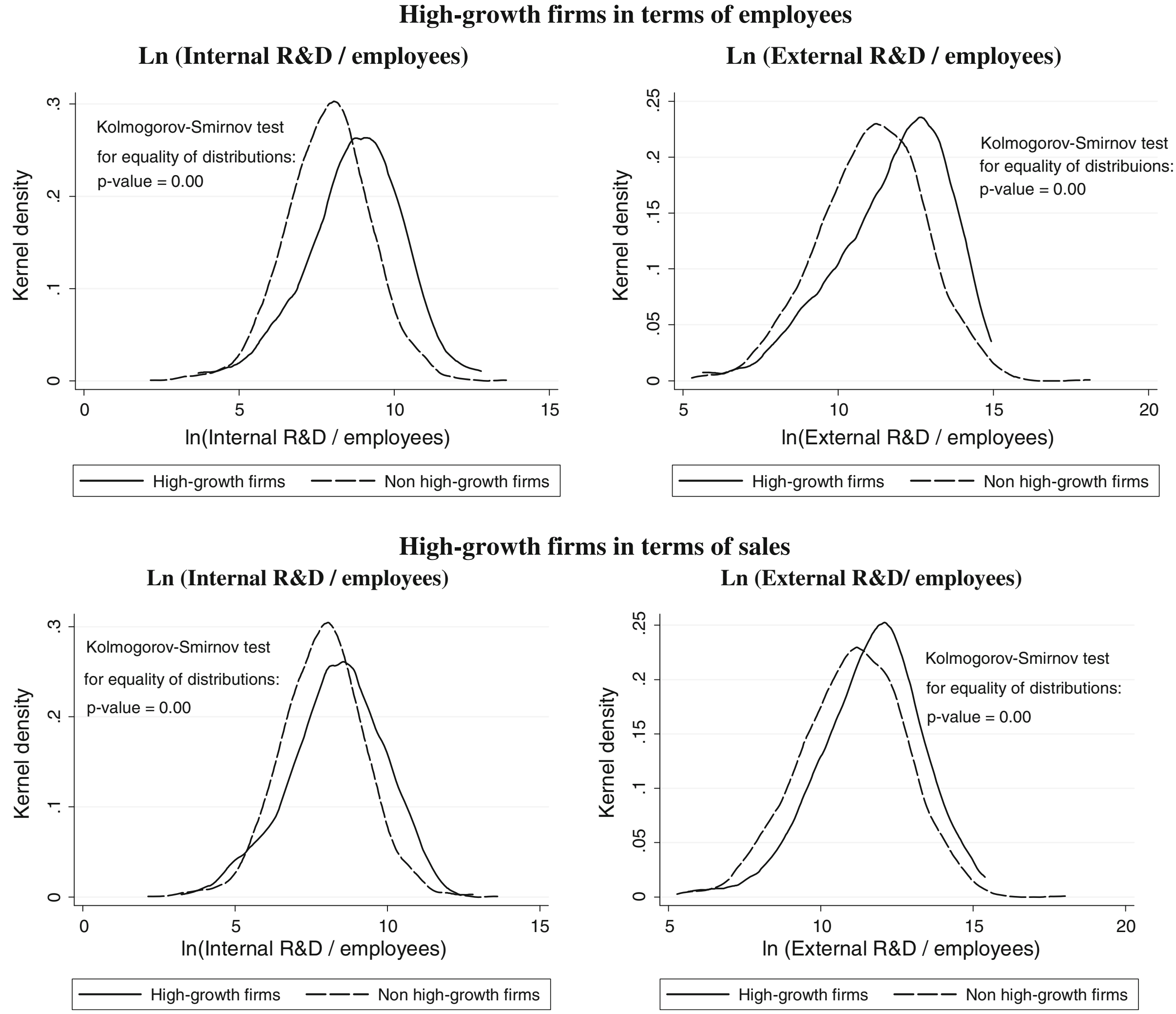

Fig. 1 Kernel densities of the internal and external R&D effort per employee

including sectoral and time dummies to correct for unobservable industry-specific characteristics. Later, we run the Heckman correction procedure for sample selection, specifically designed for probit equations.

The first equation corresponds to the selection equation which is the following:

$$P(RD = 1)_{i,t} = \delta_1 Z_{1i,t-1} + u_{1i,t} \quad (1)$$

where δ corresponds to the vector of parameters to be estimated and u is the error term. With respect to the explanatory variables introduced (Z_1), our first estimation introduces the following determinants for becoming an HGF: *Size, New, KL, Group, Coop* and *Export.*

The main equation is the probability that a firm becomes an HGF. Here, we introduce the Mill's ratio parameter previously estimated in Eq. (1). Hence, our main equations are the following:

$$P(HGFempl = 1)_{i,t} = \beta_{21} Z_{2i,t-1} + h\left(Z_{1i,t-1}, \gamma_0\right) + u_{21i,t} \quad (2)$$

$$P(HGFsales = 1)_{i,t} = \beta_{22} Z_{2i,t-1} + h\left(Z_{1i,t-1}, \gamma_0\right) + u_{22i,t} \quad (3)$$

HGFempl and *HGFsales* are latent variables, linked to a dummy variable *HGF*. *HGFempl* and *HGFsales* take a value equal to 1 if a firm becomes a HGF, and a value of 0 otherwise. β_2 is a vector of explanatory variables of the capacity to become a HGF, $h(\cdot)$ controls for the sample selection and corresponds to the inverse of Mill's ratio, and u_2 is an unknown error term. The vector Z_2 is a set of control variables that have been found in the literature to be important to explain the capacity to become an HGF. The explanatory variables that are included in this estimation are the following: *Size, New, intRD, extRD, R&D effort, KL, Group,* and *Coop.*

Second, following Coad and Rao (2008), we apply quantile regression in order not to restrict the error terms being identically distributed throughout the firm growth distribution. Our equations that estimate the growth determinants between 2004 and 2008 are:

$$grEmpl_{i,2004-2008} = \beta_{31} Z_{3i,2004} + u_{31i,t} \quad (4)$$

$$grSales_{i,2004-2008} = \beta_{32} Z_{3i,2004} + u_{32i,t} \quad (5)$$

grEmpl and *grSales* are the firm growth measured in log terms of employees and sales between 2004 and 2008. β_3 are the coefficients to be estimated and finally, u_3 is the error term. The set of explanatory variables Z_3 are the following: *Size, Group, KL, Coop, intR&Deffort* and *extR&Deffort*.

We report on quantiles 25, 50, 75, 90 and 95. The analysis of quantiles 90 and 95 will lead us to analyse the behaviour of HGFs, since those firms are located in the upper quantiles. Given that we consider growth rates over a period of time, we are able to smooth the erratic innovative pattern of firms, and we reduce concerns about endogeneity. We report bootstrapped standard errors to ensure precision in what we infer. All equations include sectoral and time dummies.

4 Results

4.1 What makes a firm an HGF?

Table 4 reports the estimated parameters of the determinants of being an HGF measured in terms of employees and sales. We report the estimations for the whole database (columns 1 and 2), in addition, for the sectoral differences between manufacturing (columns 3 and 4) and service sectors (columns 5 and 6) during the period 2004–2008.

With respect to the determinants affecting the probability of investing in R&D, the main results are the following. First, firm size shows a negative sign. Although large firms may show a larger propensity to invest in R&D than small firms, our result may be due to two different facts. On the one hand, our database consists of innovative firms, hence it is possible that the sample of small firms shows a larger propensity to invest in R&D. On the other hand, the coefficient approaches zero for manufacturing firms, while the impact is negatively larger for service firms. Given the smaller size of firms in service industries, it is quite possible to obtain a negative impact. Second, the fact of being a new firm does not present a significant impact. This result may respond to the fact that new firms may have more difficulties investing in R&D due to lack of financial resources. However, new firms may be more prone to introduce radical innovations into the market. Third, firms with a higher concentration of physical capital per employee are more prone to invest in R&D activities. Fourth, belonging to a group shows an unexpected negative sign, but it is only significant for firms in service sectors. Although we may expect that firms belonging to a group will have greater support to invest in R&D, this variable may be more related to the intensity to invest rather than the propensity to invest. Finally, firms that cooperate and export show a greater probability of investing in R&D. Both results are in line with our expectations.

Our main equation shows the following results. First, R&D effort shows a positive impact on the probability of becoming an HGF, regardless of whether we consider the growth in employees or sales. However, there are some differences between manufacturing and service sectors. The impact is significant for manufacturing firms, while for service industries the significance is limited to those firms that become an HGF measured by sales. Furthermore, the impact is higher for manufacturing industries than for service industries.

With respect to internal and external R&D investment, only internal R&D is significant. Furthermore, it is only significant for manufacturing firms. Finally, the impact is greater for manufacturing firms for both types of R&D.

In general, *Firm size* shows a significant negative impact on the probability of becoming an HGF. However, there are differences depending on the sector under consideration. For manufacturing sectors the impact is significant and negative, while for service industries the impact is positive, but not significant. Also, *New* shows a significant positive sign

Table 4 Probability of becoming an HGF. Probit estimation and Probit corrected for sample selection (measured in terms of sales and employees)

Variable	Whole database		Manufacturing industries		Service industries	
	HGF (employees)	HGF (sales)	HGF (employees)	HGF (sales)	HGF (employees)	HGF (sales)
Probability of becoming an HGF						
Determinants of innovation						
RDeffort	0.0182**	0.0302***	0.0217**	0.0367***	0.0176	0.0217**
	(0.0073)	(0.0058)	(0.0105)	(0.0077)	(0.0107)	(0.0090)
intRD	0.230**	0.148**	0.390**	0.326***	−0.0165	−0.156
	(0.115)	(0.0753)	(0.162)	(0.101)	(0.175)	(0.129)
extRD	0.0187	0.0509	0.0529	0.0534	0.0002	0.0734
	(0.0443)	(0.0338)	(0.0567)	(0.0400)	(0.0721)	(0.0648)
Control variables						
Size	−0.111***	−0.0963***	−0.227***	−0.183***	0.0193	0.0369
	(0.0191)	(0.0142)	(0.0279)	(0.0187)	(0.0277)	(0.0230)
New	0.744***	0.615***	0.705***	0.802***	0.718***	0.377**
	(0.137)	(0.125)	(0.199)	(0.166)	(0.190)	(0.189)
KL	0.0124	0.0388***	0.0624***	0.0358***	−0.0551***	0.0373**
	(0.0130)	(0.0100)	(0.0176)	(0.0124)	(0.0200)	(0.0173)
Group	0.132***	0.118***	0.219***	0.166***	0.0675	0.146**
	(0.0470)	(0.0357)	(0.0612)	(0.0431)	(0.0759)	(0.0672)
Constant	−1.718***	−1.032***	−2.688***	−2.093***	−1.428***	−1.466***
	(0.262)	(0.196)	(0.305)	(0.222)	(0.368)	(0.305)
rho	0.108	−0.136	0.263	−0.177	−0.0669	−0.0732
	(0.146)	(0.0892)	(0.280)	(0.111)	(0.173)	(0.142)
Probability of investing in R&D						
Size	−0.0456***	−0.0439***	−0.0214*	−0.0203*	−0.106***	−0.106***
	(0.0102)	(0.0102)	(0.0123)	(0.0123)	(0.0185)	(0.0186)
New	0.0969	0.103	−0.0403	−0.0448	0.485	0.476
	(0.153)	(0.153)	(0.182)	(0.182)	(0.298)	(0.297)
KL	0.0349***	0.0352***	0.0274***	0.0276***	0.0534***	0.0540***
	(0.0066)	(0.0066)	(0.0078)	(0.0078)	(0.0127)	(0.0128)
Group	−0.0345	−0.0344	−0.0308	−0.0298	−0.102*	−0.103*
	(0.0261)	(0.0261)	(0.0302)	(0.0302)	(0.0538)	(0.0537)
Coop	0.830***	0.832***	0.780***	0.781***	1.000***	1.001***
	(0.0264)	(0.0264)	(0.0301)	(0.0300)	(0.0554)	(0.0554)
Export	0.0053***	0.0052***	0.0049***	0.0048***	0.0102***	0.0100***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0024)	(0.0024)
Constant	−0.745***	−0.757***	−0.0641	−0.0714	−0.518***	−0.525***
	(0.0823)	(0.0826)	(0.0844)	(0.0843)	(0.148)	(0.148)
Observations	17,963		14,210		3,753	

HGF high-growth firms

*; **; *** indicate levels of significance equal to 10, 5 and 1 %

Standard errors in parentheses. Regressions controlled by sector and time dummies regardless of the variable considered for both industrial classifications. The explanation underlying this behaviour is that firms usually start up undersized and hence will have a larger propensity to become an HGF. The impact is similar when we consider HGFs measured in terms of employees, while the impact is significantly different between manufacturing and service industries when we consider the probability of becoming an HGF measured in terms of sales, since the impact is larger for manufacturing industries and smaller for service industries.

Hence, our results are in line with previous empirical evidence in which small and young firms are more prone to be an HGF. The fact that small and young firms are more prone to be an HGF highlights the role of entrepreneurial firms in pushing the economy. This is in line with Braunerhjelm et al. (2010), among others, who remark that entrepreneurship is the missing link in endogenous growth analysis, the generation of knowledge at firm level and aggregate perspective. Implementing different econometric techniques, those authors find robust evidence for entrepreneurship being one important source of growth and find evidence of direct links with start-up rates and HGFs.

In general, the variables *KL* and *Group* show a positive impact on the probability of being a HGF. However, when we distinguish by sectors some differences appear. First, *KL* has a significant and positive sign for manufacturing industries regardless of the measure, while for services the impact is negative and significant on the probability of becoming an HGF measured in terms of employees. This result is in line with our expectations since those firms which are intensive in capital have a larger propensity to be an HGF than firms with a low propensity to invest in R&D. *Group* is always significant for manufacturing firms, while it is only significant for service firms when we consider HGFs measured in terms of sales.

Hence, our first approach to the determinants of HGFs shows that investment in R&D per employee is crucial to become an HGF. This holds particularly for manufacturing (relative to services), and particularly for internal R&D (relative to external R&D).

4.2 Determinants of firm growth during the period 2004–2008

Table 5 shows the results of estimating the growth of firms in terms of employees and sales respectively, between 2004 and 2008.[7] We should mention that the magnitudes of the OLS coefficients are different from the coefficient of the median quantile. Hence, quantile estimations provide more details about the sensitivity of the determinants of growth distribution and will allow us to analyse the behaviour of HGFs by analysing the upper distribution (see also the previous analysis by Coad and Rao (2010)).

First, our results suggest that firm growth is positively associated with innovation effort. However, we must highlight different characteristics. On the one hand, there is a positive significant impact of internal R&D investment per employee for firms with growth rates located in quantiles superior to 0.75. Furthermore, the impact of internal R&D shows an increasing impact on the quantile distribution. On the other hand, the external R&D effort shows a positive sign, but it is only significant up to quantile 0.50 for manufacturing sectors and up to quantile 0.75 for service sectors. Furthermore, the impact of external R&D shows a decreasing pattern over the quantiles. Both results are accomplished for both measures of firm growth, employees and sales. Since HGFs are located in the quantile 0.90 and 0.95, we may consider that, in general, HGFs are positively affected by the effort of internal R&D.

Intense competition challenges firms to achieve a balance between internal and external R&D. The literature analysing the complementarities between internal and external R&D is not conclusive. While there have been previous analyses which have suggested the existence of complementarities between both innovation strategies (Bönte 2003; Cassiman and Veugelers 2006; Beneito 2006; Griffith et al. 2003, 2004; Lokshin et al. 2008), others have found that both strategies are substitutes (Audretsch et al. 1996; Basant and Fikkert 1996; Blonigen and Taylor 2000). Our results are not able to suggest whether there exists a complementarity or a substitution effect; they do, however, shed light on the fact that those variables may have a different impact depending on the firm growth rates. While external R&D may be important for firms in the lower growth distribution, internal R&D seems to be more crucial for firms in the upper growth distribution.

[7] Also in the Annex, there are graph quantiles of the marginal effects of the internal and external R&D effort on growth (see Graph A-1).

Table 5 Bootstrapped quantile regressions of the determinants of firm growth measured by employees and sales; 5-year growth

Variable	*grEmpl* (2004–2008)						*gr*Sales (2004–2008)					
	OLS	q.25	q.50	q.75	q.90	q.95	OLS	q.25	q.50	q.75	q.90	q.95
Determinants of innovation												
intR&Deffort	0.0014**	0.0009	0.0002	0.0012***	0.0026**	0.0025*	0.0017*	0.0013	0.0010*	0.0016	0.0043***	0.0036**
	(0.0006)	(0.0008)	(0.0005)	(0.0004)	(0.0011)	(0.0013)	(0.0009)	(0.0008)	(0.0006)	(0.0010)	(0.0011)	(0.0015)
extR&Dffort	0.0014**	0.0017*	0.0016***	0.0012	0.0011	0.0029*	0.00149	0.0021***	0.0019***	0.0018***	0.0014	0.0025
	(0.0006)	(0.0009)	(0.0004)	(0.0008)	(0.0013)	(0.0015)	(0.0009)	(0.0007)	(0.0007)	(0.0006)	(0.0014)	(0.0021)
Firm characteristics												
Firm size	−0.0204***	0.0053	−0.014***	−0.0345***	−0.0649***	−0.0689***	−0.0033	0.0129*	−0.0075	−0.0367***	−0.0600***	−0.0893***
	(0.0058)	(0.0057)	(0.0039)	(0.0030)	(0.0072)	(0.0140)	(0.0081)	(0.0069)	(0.0080)	(0.0060)	(0.0149)	(0.0146)
Group	0.0144	−0.0272**	−0.0024	0.0215	0.0381*	0.0459	0.0119	−0.0141	−0.0002	0.0332***	0.0608*	0.125***
	(0.0138)	(0.0127)	(0.0114)	(0.0140)	(0.0227)	(0.0324)	(0.0198)	(0.0122)	(0.0187)	(0.0118)	(0.0331)	(0.0484)
KL	0.0243***	0.0207***	0.0170***	0.0186***	0.0134***	0.0177**	0.0101	0.0092*	0.0126***	0.0124**	0.0188*	0.0169
	(0.0046)	(0.0051)	(0.0028)	(0.0043)	(0.0049)	(0.0082)	(0.0070)	(0.0055)	(0.0047)	(0.0048)	(0.0096)	(0.0127)
Coop	0.0189	0.0104	0.0151*	0.0208*	−0.0096	−0.0204	0.0257	0.00808	0.0059	0.0204	−0.0009	0.0086
	(0.0133)	(0.0114)	(0.0089)	(0.0120)	(0.0160)	(0.0268)	(0.0175)	(0.0170)	(0.0156)	(0.0156)	(0.0237)	(0.0389)
Constant	0.0309	0.0150	0.105	0.125	0.275	0.276	0.426***	0.419	0.442	0.503**	0.494	0.602
	(0.049)	(0.0807)	(0.290)	(0.280)	(0.337)	(0.442)	(0.0761)	(0.263)	(1.346)	(0.243)	(0.437)	(0.978)
R^2/Pseudo R^2	0.086	0.051	0.058	0.089	0.137	0.168	0.092	0.058	0.064	0.094	0.121	0.127
Observations	3,807											

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Regressions controlled by sector and time dummies

Table 6 Bootstrapped quantile regressions of the determinants of firm growth measured by employees and sales; 5-year growth

Variable	*grEmpl* (2004–2008)						*grSales* (2004–2008)					
	OLS	q.25	q.50	q.75	q.90	q.95	OLS	q.25	q.50	q.75	q.90	q.95
Manufacturing industries												
Determinants of innovation												
int R&D effort	0.0016**	0.0016*	0.0005	0.0014**	0.0027***	0.0013	0.0018**	0.0021**	0.0015*	0.0014	0.0037*	0.0031*
	(0.0007)	(0.0009)	(0.0005)	(0.0007)	(0.0008)	(0.0014)	(0.0009)	(0.0009)	(0.0009)	(0.0008)	(0.0019)	(0.0018)
ext R&D effort	0.0016**	0.0020***	0.0017***	0.0012**	0.0018*	0.0024**	0.0018**	0.0018	0.0020**	0.0020***	0.0007	0.0023
	(0.0006)	(0.0006)	(0.0003)	(0.0005)	(0.0010)	(0.0011)	(0.0009)	(0.0011)	(0.0009)	(0.0007)	(0.0014)	(0.0023)
Firm characteristics												
Firm size	−0.0321***	−0.0016	−0.0167***	−0.0387***	−0.0664***	−0.0744***	−0.0207***	0.0047	−0.0091	−0.0425***	−0.0743***	−0.101***
	(0.0065)	(0.0065)	(0.0048)	(0.0042)	(0.0083)	(0.0114)	(0.0074)	(0.0089)	(0.0089)	(0.0068)	(0.0140)	(0.0200)
Group	0.0183	−0.0188	−0.0098	0.0112	0.0184	0.0146	0.0291	−0.0065	0.0005	0.0420***	0.0822**	0.122*
	(0.0140)	(0.0122)	(0.0092)	(0.0120)	(0.0183)	(0.0235)	(0.0187)	(0.0262)	(0.0176)	(0.0127)	(0.0341)	(0.0632)
KL	0.0310***	0.0238***	0.0199***	0.0227***	0.0269***	0.0232***	0.0216***	0.0195**	0.0188***	0.0148**	0.0304***	0.0261*
	(0.0049)	(0.0040)	(0.0037)	(0.0037)	(0.0075)	(0.0084)	(0.0070)	(0.0076)	(0.0054)	(0.0060)	(0.0061)	(0.0148)
Coop	0.0134	0.0152	0.0176*	0.0150	−0.0192	−0.0293	0.0252	0.0179	0.0011	0.0152	0.0085	−0.0022
	(0.0132)	(0.0154)	(0.0098)	(0.0103)	(0.0168)	(0.0366)	(0.0175)	(0.0202)	(0.0123)	(0.0168)	(0.0304)	(0.0487)
Constant	−0.130***	−0.188	−0.0938	−0.0369	0.0687	0.150	−0.238***	−0.296	−0.217*	−0.0977	−0.102	0.0088
	(0.0359)	(0.185)	(0.0635)	(0.228)	(0.144)	(0.155)	(0.0508)	(0.226)	(0.117)	(0.341)	(0.268)	(0.443)
R^2/Pseudo R^2	0.078	0.046	0.039	0.057	0.073	0.084	0.077	0.051	0.049	0.066	0.085	0.106
Observations	3,026											
Service industries												
Determinants of innovation												
int R&D effort	0.0012	−0.0013	−0.0015**	−0.0010	0.0022	0.0075	0.0015	−0.0004	−0.000	0.0028*	0.0058*	0.00330
	(0.0019)	(0.0018)	(0.0007)	(0.0023)	(0.0029)	(0.0048)	(0.0026)	(0.0017)	(0.0021)	(0.0016)	(0.0034)	(0.0051)
ext R&D effort	0.0006	0.0008	0.0020	0.0029	−0.0008	0.0058	0.0002	0.0015	0.0024	0.0013	0.0043	0.0035
	(0.0021)	(0.0017)	(0.0013)	(0.0021)	(0.0042)	(0.0037)	(0.0028)	(0.0029)	(0.0023)	(0.0024)	(0.0044)	(0.0080)
Firm characteristics												
Firm size	0.0123	0.0149	−0.0074	−0.0209	−0.0407	−0.0158	0.0434**	0.0468***	0.0021	−0.0059	−0.0026	−0.0408
	(0.0130)	(0.0158)	(0.0122)	(0.0174)	(0.0352)	(0.0296)	(0.0220)	(0.0171)	(0.0124)	(0.0186)	(0.0306)	(0.0434)
Group	0.0178	−0.0257	0.0173	0.0554	0.159*	0.161***	−0.0310	−0.0511	0.0165	−0.0175	0.0036	0.174
	(0.0398)	(0.0406)	(0.0231)	(0.0401)	(0.0833)	(0.0611)	(0.0571)	(0.0611)	(0.0516)	(0.0453)	(0.0713)	(0.124)

Table 6 continued

Variable	*grEmpl* (2004–2008)						*grSales* (2004–2008)					
	OLS	q.25	q.50	q.75	q.90	q.95	OLS	q.25	q.50	q.75	q.90	q.95
KL	0.0050	0.0140*	0.0037	−0.0065	−0.0164	0.0027	−0.0243	−0.0198	−0.0097	−0.0112	−0.0035	0.0133
	(0.0104)	(0.0081)	(0.0084)	(0.0108)	(0.0161)	(0.0230)	(0.0176)	(0.0153)	(0.0163)	(0.0115)	(0.0123)	(0.0199)
Coop	0.0457	−0.0172	0.0232	0.0714	0.0525	0.0901	0.0321	−0.0022	0.0326	0.0373	−0.0507	0.0560
	(0.0413)	(0.0292)	(0.0146)	(0.0457)	(0.0569)	(0.0788)	(0.0532)	(0.0499)	(0.0262)	(0.0486)	(0.0489)	(0.0942)
Constant	−0.158	−0.116	−0.0060	0.0582	0.0612	−0.203	0.369**	0.404	0.398	0.429	0.428	0.162
	(0.110)	(0.349)	(0.372)	(0.391)	(0.329)	(0.554)	(0.171)	(0.934)	(1.132)	(0.407)	(1.281)	(1.300)
R^2/Pseudo R^2	0.052	0.052	0.032	0.074	0.127	0.164	0.104	0.068	0.046	0.089	0.084	0.113
Observations	781											

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Regressions controlled by sector and time dummies

Second, *Firm size* shows a negative impact on firm growth regardless of the variable. Furthermore, the impact decreases over the quantiles, so it becomes more negative among firms that grow faster (those in the upper quantiles, q. 90 and q. 95). However, for those firms in the lower quantiles the impact is positive (but non-significant). Hence, our results reject Gibrat's law and show that smaller firms have more propensity to grow and, in particular, among the upper quantiles. A possible explanation for the stronger effect of firm size in the higher quantiles of the growth distribution may be that they mainly consist of the smallest firms, where the strongest deviation from Gribrat's law applies, since the smallest firms are further away from the MES and hence are in need of high growth.

Third, the variable *Group* shows an increasing impact across the quantile distribution. However, there is a different impact depending on how firm growth is measured. First, when we consider employment growth, the impact is only significant for quantiles 0.25 and 0.90, while when we consider sales growth the impact is significant for quantiles superior to 0.50. Second, the impact of *Group* is larger for sales growth. Consequently, we may say that those firms that are in the lower quantiles, and as consequence present negative growth rates, are not affected by belonging to a group and, if they obtain lower growth rates, it is not directly related to the fact that they belong to a group; whereas belonging to a group of firms affects firms in the upper quantiles positively.

With respect to physical capital investment (*KL*), this variable also shows a positive influence on firm growth. However, the trend is slightly different when analysing the growth rates of employees and sales. On the one hand, the impact decreases throughout the distribution for employee growth. On the other hand, investment shows an increasing impact on sales growth across quantiles. Nevertheless, the impact of investments per worker is not significant for those firms in the lower and upper quantiles. Furthermore, the impact is higher for employment growth. Therefore, our results show that a larger investment per worker will increase the growth rate.

With respect to variable cooperation, this does not show a significant effect, although its impact is positive. The exception is quantiles 0.50 and 0.75 of employment growth, which show a significant positive impact.

4.3 Sectoral differences

The next step is to distinguish between manufacturing and service industries. To that end, our results show some interesting results (Table 6). First of all, the R&D intensity shows a positive sign, but it is only significant for manufacturing industries while firm growth for service firms is not significantly affected by R&D intensity.

Second, firm size in general shows a significant negative sign for manufacturing industries, yet does not show a significant impact on firm growth (with the exception of the lower quantile of sales growth). This difference highlights the importance among manufacturing firms of achieving a minimum efficient size (see previous results for Spanish firms in Teruel 2010).

With respect to the variable *Group*, this indicates a pattern of increase but is only significant for the upper quantiles of the sales growth of manufacturing firms and the employment growth of service firms.

Regarding the intensity of investment per employee (*KL*), this variable is highly significant for manufacturing industries across the distribution, while in general the impact for service industries is non-significant. This result is in line with the one obtained by firm size, where the capital intensity is important in order for a firm to be competitive in the market.

Finally, the cooperation parameter shows a non-significant impact on firm growth, regardless of the firm growth measure and the sectoral classification.

5 Conclusions

Since the seminal works by David Birch and his colleagues, an increasing number of studies have focused on HGFs due to their potential capacity to create employment. Although results related to the contribution of HGFs to the generation of new jobs and the statistical techniques used have been questioned in recent years, it is clear that the contribution of HGFs to job creation is non-negligible. In general, these studies found that the capacity to generate new jobs among HGFs is higher than their counterparts, but HGFs represent a small number of firms.

As we have seen in our previous literature revision, nowadays there is a better understanding of the HGFs' characteristics, their role in production and employment, and their impact on structural change, specifically R&D and innovation. Analyses of this sort are fundamental for countries such as Spain that needs an industrial policy that will reorganize its economy and overcome the current crisis. For Spain in particular, Schreyer (2000) found that HGFs contribute a disproportionately large amount of job creation among the firms studied.

Here we have two aims. First, we aim to analyse the determinants for becoming an HGF. Second, we analyse the innovation determinants on firm growth. Our sample corresponds to a panel of 3,807 Spanish manufacturing and service firms during the period 2004–2008 from the PITEC database. We consider firm growth in terms of sales and employees. When measured in terms of sales, the sample contained 419 HGFs (11.01 %), and in terms of employees 198 (5.12 %), hence our results are in line with previous results at country level.

Our main results are the following. As a first step, a probit analysis corrected for sample selection was applied and this shows that the Spanish firms most likely to become HGFs are small and new firms. With respect to innovation performance, we observe that firms that invest in R&D demonstrate a greater propensity for becoming an HGF. For the second step, we applied a quantile regression to measure which variables affect firm growth. Our results show that firm growth is negatively affected by firm size, but positively affected by belonging to a group and by investment per employee. With respect to the variables that measure innovation effort, investment in internal and external R&D per employee has a significant positive impact, in particular for manufacturing firms. However, a different pattern appears depending on whether we consider investment in internal or external R&D. On the one hand, internal R&D per employee presents an increasing impact which is significant in the higher quantiles. On the other hand, investment in external R&D per employee shows a decreasing impact which is significant up to the median.

Our results suggest the effects of R&D on firm growth differ between R&D sources and industries. While investment in internal R&D is an important innovative activity for the fastest growing firms, this is not significant for firms that grow more slowly. Furthermore, there are differences between manufacturing and service firms. Our results show that manufacturing firms are significantly affected by

R&D investment per employee, while this shows a flatter impact on firm growth in service firms. Our results may be related to the different nature of innovation within each sector. While innovation may play a crucial role for manufacturing firms, this may not be the case for a significant portion of the service firms.

From the viewpoint of policy makers, our results suggest that Spanish public policies should be pursued to promote innovation and growth among a cluster of young and dynamic firms that facilitate job creation and greater improvements in efficiency. Up to now, Spanish public policies have promoted firms' innovation through non-discriminatory tools, like horizontal grants or tax reductions, which have generated moderate social returns. Our results recommend the implementation of public policies to promote private R&D addressed at small groups of firms with high potential growth, in particular between manufacturing firms.

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